Cadmium

CAS No. 7440-43-9

General Information

Elemental cadmium is a silver-white metal. In nature, it usually is found combined with other elements such as oxygen (cadmium oxide), chlorine (cadmium chloride), or sulfur (cadmium sulfate, cadmium sulfide). Cadmium does not corrode easily and has many uses. In industry and consumer products, it is used in batteries, pigments, metal coatings, and plastics. Cadmium enters the environment from the weathering and mining of rocks and minerals that contain cadmium. Contaminated water sources, foods, and combustion sources may also result in human exposure. Cadmium exposure occurs from inhalation of cigarette smoke. Cadmium can be absorbed by inhalation or ingestion. Exposure to cadmium may occur in industries, such as mining or electroplating, which use or produce the chemical.

Cadmium and its compounds are toxic. Once absorbed into the body, cadmium may remain for decades. Low-level chronic exposures over many years may result in

Table 5. Cadmium

Geometric mean and selected percentiles of blood concentrations (in µg/L) for the U.S. population aged 1 year and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 1 and older	.412 (.386-.439)	< LOD	< LOD	.300 (.300-.400)	.600 (.500-.600)	1.00 (.900-1.00)	1.30 (1.20-1.40)	7970
Age group								
1-5 years	*	< LOD	< LOD	< LOD	.300 (<LOD-.300)	.400 (.300-.400)	.400 (.300-.400)	723
6-11 years	*	< LOD	< LOD	< LOD	.300 (<LOD-.300)	.400 (.300-.400)	.400 (.400-.500)	905
12-19 years	.333 (.309-.360)	< LOD	< LOD	.300 (<LOD-.300)	.300 (.300-.400)	.800 (.600-.900)	1.10 (.900-1.10)	2135
20 years and older	.468 (.436-.502)	< LOD	< LOD	.400 (.300-.400)	.600 (.600-.700)	1.00 (1.00-1.10)	1.50 (1.40-1.60)	4207
Gender								
Males	.403 (.376-.431)	< LOD	< LOD	.400 (.300-.400)	.600 (.500-.600)	1.00 (.900-1.00)	1.30 (1.20-1.50)	3913
Females	.421 (.394-.451)	< LOD	< LOD	.300 (.300-.400)	.600 (.500-.600)	1.00 (.800-1.00)	1.30 (1.10-1.40)	4057
Race/ethnicity								
Mexican Americans	.395 (.368-.423)	< LOD	< LOD	.400 (.300-.400)	.400 (.400-.500)	.700 (.700-.900)	1.10 (.900-1.30)	2743
Non-Hispanic blacks	.393 (.367-.421)	< LOD	< LOD	.300 (.300-.400)	.600 (.500-.600)	1.00 (.800-1.00)	1.40 (1.20-1.50)	1842
Non-Hispanic whites	.420 (.388-.456)	< LOD	< LOD	.400 (.300-.400)	.500 (.500-.600)	1.00 (.900-1.10)	1.30 (1.20-1.40)	2715

< LOD means less than the limit of detection, which is 0.3 µg/L.

* Not calculated. Proportion of results below limit of detection was too high to provide a valid result.

accumulation of cadmium in the kidneys. When the amount of cadmium exceeds the ability of the kidney cells to produce a binding protein that keeps the cadmium biologically inactive, serious kidney damage may occur. Chronic ingestion also has produced painful osteomalacia, a bone disorder similar to rickets in children. Large, acute airborne exposures to dusts and fumes, as occurs for example from welding on cadmium-alloyed metals, may result in severe swelling of the lungs (edema) and subsequent scarring (fibrosis). Other cadmium toxicity, as seen in animal studies, includes reproductive and teratogenic effects. IARC has determined that cadmium is a known human carcinogen. Information about external exposure (environmental levels) and health effects is available from the EPA IRIS Web site at http://www.epa.gov/iris and from ATSDR at http://www.atsdr.cdc.gov/toxprofiles.

Interpreting Blood and Urine Cadmium Levels Reported in the Tables

In the NHANES 1999-2000 sample, blood cadmium levels were measured in all participants aged 1 year and older, and urine cadmium levels were measured in a sample of people aged 6 years old and older. Finding a measurable amount of cadmium in the blood or urine does not mean that the level of cadmium causes an adverse health effect. OSHA (1998) has developed criteria for evaluating occupational exposures. These occupational criteria are to be used to assess chronic

Table 6. Cadmium

Geometric mean and selected percentiles of urine concentrations (in µg/L) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.326 (.306-.347)	.110 (.090-.110)	.190 (.170-.200)	.330 (.310-.350)	.590 (.550-.640)	1.01 (.910-1.11)	1.36 (1.21-1.53)	2465
Age group								
6-11 years	.211 (.180-.248)	.080 (<LOD-.110)	.120 (.100-.160)	.210 (.170-.260)	.340 (.290-.380)	.460 (.380-.900)	.760 (.400-1.61)	340
12-19 years	.218 (.197-.242)	.070 (<LOD-.100)	.140 (.120-.160)	.240 (.210-.270)	.360 (.330-.420)	.510 (.440-.550)	.630 (.520-.780)	719
20 years and older	.368 (.344-.394)	.110 (.110-.130)	.200 (.180-.220)	.390 (.360-.420)	.670 (.620-.740)	1.11 (1.00-1.25)	1.51 (1.33-1.69)	1406
Gender								
Males	.347 (.316-.381)	.110 (.100-.130)	.190 (.170-.220)	.360 (.320-.380)	.620 (.540-.710)	1.03 (.920-1.30)	1.61 (1.21-1.89)	1227
Females	.307 (.282-.334)	.080 (.060-.110)	.170 (.140-.190)	.340 (.300-.350)	.590 (.540-.630)	.960 (.840-1.05)	1.25 (1.13-1.37)	1238
Race/ethnicity								
Mexican Americans	.310 (.280-.344)	.110 (.090-.130)	.170 (.150-.200)	.290 (.270-.320)	.600 (.500-.670)	.950 (.820-1.06)	1.24 (1.06-1.45)	884
Non-Hispanic blacks	.441 (.386-.504)	.160 (.130-.170)	.250 (.200-.300)	.440 (.390-.530)	.750 (.670-.890)	1.36 (1.13-1.48)	1.72 (1.44-2.00)	568
Non-Hispanic whites	.311 (.285-.338)	.100 (.080-.110)	.160 (.140-.190)	.330 (.300-.350)	.560 (.510-.620)	.980 (.830-1.12)	1.33 (1.13-1.61)	822

< LOD means less than the limit of detection, which is 0.04 µg/L.

workplace exposure. For blood cadmium, the criterion is 5 µg/L of blood; for urine cadmium, the criterion is 3 µg/gram of creatinine. Occupational criteria are provided here for comparison only, not to imply a safety level for general population exposure. The 95th percentile for blood cadmium reported in Table 5 is less than the OSHA criterion for blood cadmium, and the 95th percentile for urine cadmium shown in Table 7 is less than the OSHA criterion for urine cadmium.

In a previous study of a nonrandom subsample from NHANES III (Paschal et al., 2000), levels of cadmium were similar to levels in this NHANES 1999-2000 sample. In this *Report*, geometric mean levels of blood cadmium for the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, log serum cotinine and urinary creatinine. Blood cadmium levels increased with each higher age group. Females had slightly higher levels than males. Mexican Americans had higher blood cadmium levels than non-Hispanic whites or non-Hispanic blacks. Similar relationships for age, gender, and smoking were found in the study of NHANES III participants (Paschal et al., 2000). It is unknown whether differences between ages, genders, or races/ethnicities represent differences in exposure, body-size relationships, or metabolism.

Blood cadmium reflects recent and cumulative exposures, whereas urinary cadmium reflects losses from the kidney as protein binding is exceeded (Lauwerys and

Table 7. Cadmium (creatinine adjusted)

Geometric mean and selected percentiles of urine concentrations (in µg/gram of creatinine) for the U.S. population aged 6 years and older, National Health and Nutrition Examination Survey, 1999-2000.

	Geometric mean (95% conf. interval)	Selected percentiles (95% confidence interval)						Sample size
		10th	25th	50th	75th	90th	95th	
Total, age 6 and older	.307 (.290-.324)	.122 (.115-.134)	.188 (.174-.200)	.296 (.274-.315)	.496 (.466-.527)	.797 (.743-.850)	1.03 (.916-1.14)	2465
Age group								
6-11 years	.232 (.202-.265)	.120 (.113-.145)	.170 (.145-.191)	.221 (.200-.242)	.299 (.268-.342)	.414 (.321-.700)	.569 (.342-1.99)	340
12-19 years	.164 (.151-.179)	.088 (.070-.106)	.121 (.113-.130)	.160 (.152-.173)	.230 (.198-.258)	.315 (.267-.364)	.376 (.321-.500)	719
20 years and older	.353 (.333-.373)	.145 (.122-.163)	.220 (.200-.240)	.351 (.332-.375)	.581 (.534-.617)	.852 (.798-.947)	1.13 (.977-1.24)	1406
Gender								
Males	.271 (.252-.291)	.112 (.101-.128)	.164 (.153-.183)	.255 (.240-.271)	.421 (.385-.457)	.720 (.636-.785)	.890 (.794-1.13)	1227
Females	.345 (.322-.370)	.143 (.121-.161)	.213 (.195-.232)	.344 (.319-.364)	.566 (.509-.614)	.857 (.786-.953)	1.13 (.966-1.31)	1238
Race/ethnicity								
Mexican Americans	.286 (.264-.311)	.135 (.120-.145)	.176 (.161-.188)	.265 (.246-.289)	.432 (.377-.483)	.759 (.588-.899)	.968 (.787-1.13)	884
Non-Hispanic blacks	.287 (.256-.321)	.115 (.096-.142)	.171 (.161-.186)	.274 (.249-.313)	.500 (.420-.556)	.740 (.659-.841)	.929 (.782-1.06)	568
Non-Hispanic whites	.311 (.288-.336)	.120 (.108-.140)	.187 (.170-.205)	.302 (.271-.333)	.509 (.457-.570)	.817 (.751-.912)	1.12 (.916-1.33)	822

Hoet, 2001; Satarug et al. 2002). In occupational studies of exposed males, urinary cadmium thresholds corresponding to significant increased excretion of renal protein markers have ranged from 2.4 μg/gram to 11.5 μg/gram creatinine. A threshold of 10 μg/gram creatinine has been suggested for the occurrence of reversible low-molecular-mass proteinuria (functional effect) and subsequent loss of renal filtration reserve capacity (Roels et al., 1999). This threshold also approximates the critical cadmium concentration in the renal cortex of 200 μg of cadmium per gram of tissue. In this *Report*, geometric mean levels of urinary cadmium for the demographic groups were compared after adjustment for the covariates of race/ethnicity, age, gender, log serum cotinine and urinary creatinine. There were no differences in the adjusted geometric means of urine cadmium for the race/ethnicity categories. The 12-19-year-old group had lower urinary cadmium levels than either the 6-11-year-old or 20-year-old and older age groupings. Urinary cadmium levels in males were lower than in females. It is unknown whether differences between ages or genders represent differences in exposure, body-size relationships, or metabolism.

Whether cadmium at the levels reported here is a cause for health concern is not yet known; more research is needed. Measuring cadmium at these levels in blood and urine is possible because of advances in analytical chemistry. These data provide physicians with a reference range so they can determine whether people have been exposed to higher levels of cadmium than those found in the general population. These data also will help scientists plan and conduct research about cadmium exposure and health effects.